Advanced Neutron Absorber Project

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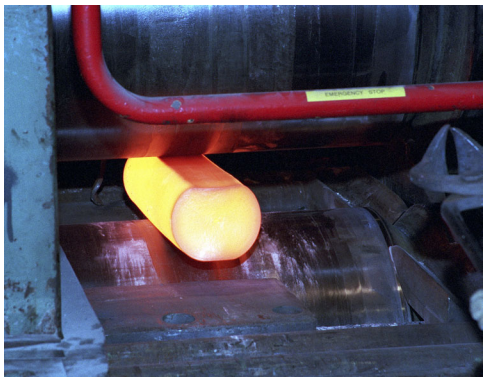
Improving spent nuclear fuel storage applications by developing a neutron absorbing structural material that is weldable and corrosion resistant is the INEEL's Nuclear Materials Engineering and Disposition department's goal.

Purpose of the Project

Safe, long-term storage of the U.S. Department of Energy (DOE)-owned spent nuclear fuel requires a corrosion resistant, long-lasting material that absorbs thermal neutrons emitted by spent nuclear fuel. The National Spent Nuclear Fuel Program (NSNFP) at the INEEL is investigating gadolinium-alloyed nickel-based alloys for potential use in neutron absorber structural components.

New Alloy

The NSNFP is developing a corrosion-resistant, nickel-chromium-molybdenum alloy containing gadolinium for criticality control in the DOE standardized spent nuclear fuel storage canister. These canisters—being designed to package all DOE spent nuclear fuel—will be stored in the waste package at the Yucca Mountain Repository. Gadolinium (Gd) is a potent neutron-absorbing element which has the highest available neutron absorption cross section. To meet the functional requirements for a structural material that will be used as an insert in the standardized canister, gadolinium must be alloyed into a corrosion resistant structural metal that will meet American Society of mechanical Engineers (ASME) code requirements.



INEEL scientists and engineers are creating new structural materials that will protect workers and the environment from neutrons given off by spent nuclear fuel.

The criticality analysis results push the alloy development towards the highest attainable gadolinium level. However, the gadolinium has no solubility in the matrix of either a stainless steel or nickel-based metal and is present as a second phase. This has implications for the corrosion resistance and mechanical properties of the resulting alloys. This alloy may be used for the internal baskets of the standardized DOE spent nuclear fuel canister and serve the following three functions: structural support of the fuel assemblies, spent nuclear fuel geometry control, and nuclear criticality safety.

Characterization of the nickel-chromium-molybdenum-gadolinium alloys will be performed for primary processing behavior, microstructure, mechanical properties, weldability, corrosion resistance and neutron absorption behavior. The data will be used to establish an American Society

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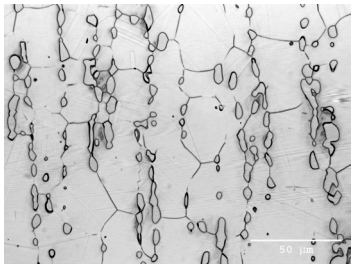


This micrograph shows circular Gadolinium forms embedded in other material to absorb neutrons.

for Testing and Materials (ASTM) material specification. The specification is needed for subsequent ASME code approval and the U.S. Nuclear Regulatory Commission (NRC) approval for subsequent use by the nuclear industry. Acceptance by the ASME and the NRC is currently pending.

Unique Capabilities

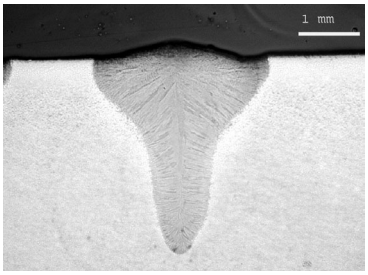
Although it has the highest thermal neutron absorption cross section, gadolinium has not historically been used because of cost. A substantial increase in the mining of rare earth elements over the last fifteen years has resulted in increased availability of gadolinium as a byproduct material. These alloys may also be used as components in commercial spent nuclear fuel transportation packages.

Work in Progress

Initial heats of material have been measured to determine the hot workability, microstructure, mechanical properties, weldability, corrosion resistance, and neutron absorption properties of the material. Work is continuing to define the chemistry ranges and minimum mechanical properties for the final ASTM Specification submittal.

Benefits

Gadolinium is a readily available, relatively low-cost material that has a significantly higher thermal neutron adsorption cross-section than boron. It can be alloyed with a corrosion resistant nickel-chromium-molybdenum alloy matrix that will provide a uniformly distributed, gadolinium rich second phase. The alloy is weldable and can be formed into structural shapes such as plate and strip. With these characteristics, gadolinium-stainless steel alloys can potentially provide the nuclear criticality safety required for interim storage, transport, and final disposal of spent nuclear fuel.



This image shows the compatability of this new material for electron beam welding.

Major Project Activities